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## REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

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|---|---|
| 1. REPORT NUMBER: TOP 3-2-607 | 2. GOVT ACCESSION NO.: AD-A139813 |
| 3. RECIPIENT'S CATALOG NUMBER | |
| 4. TITLE (and Subtitle): US ARMY TEST AND EVALUATION COMMAND TEST OPERATIONS PROCEDURE "DETERMINATION OF RANGE DANGER AREAS" | 5. TYPE OF REPORT & PERIOD COVERED: INTERIM |
| | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s) | 8. CONTRACT OR GRANT NUMBER(s) |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS: US ARMY ABERDEEN PROVING GROUND (STEAP-MT-M) ABERDEEN PROVING GROUND, MARYLAND 21005 | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: DARCOM-R 310-6 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS: US ARMY TEST AND EVALUATION COMMAND (DRSTE-AD-M) ABERDEEN PROVING GROUND, MARYLAND 21005 | 12. REPORT DATE: 21 April 1983 |
| | 13. NUMBER OF PAGES: 19 |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) | 15. SECURITY CLASS. (of this report): Unclassified |
| | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES



19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Danger areas
Range danger areas

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Provides guidance for acquiring data to establish danger areas for training, target practice, and combat when using conventional weapons and ammunition, small rockets, and guided missiles.

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

DRSTE-RP-702-102
Test Operations Procedure 3-2-607 (INTERIM) 21 April 1983
AD No.

# DETERMINATION OF RANGE DANGER AREAS



1. SCOPE. This TOP provides guidance for acquiring the data required by US Army Training and Doctrine Command (TRADOC) to establish danger areas for training, target practice, and combat, when using conventional weapons and ammunition, small rockets, guided missiles, and training rounds for nuclear and chemical ammunition. Rockets and missiles are excluded from this TOP as is ammunition with live nuclear or chemical warheads. This TOP does not apply to range danger areas for DARCOM's proving grounds where different range safety procedures apply.

The Department of the Army has given the US Army Materiel Development and Readiness Command (DARCOM) the responsibility for providing to TRADOC the data it requires to establish its range danger areas. Once the data are obtained, TRADOC follows the procedures outlined in AR 385-63[1] for conventional weapons and ammunition and AR 385-62[2] for rockets and missiles, to establish the danger areas, with appropriate margins of safety, for each caliber and type of weapon and each type of projectile and missile. This TOP provides a standardized method of developing data during development and production testing to be provided to TRADOC by DARCOM. The actual procedures for obtaining the data are described in various TOPs which are referenced below.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities. Facilities are covered in the referenced TOPs.

2.2 Instrumentation. Instrumentation is covered in the referenced TOPs.

[1]Footnote numbers correspond to reference numbers in Appendix B.

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## 3. REQUIRED TEST CONDITIONS.

3.1 Planning the Test. Data requirements and conditions that should be considered in planning a range danger area test for a specific weapon-ammunition combination follow:

a. Ranges that the projectile attains when fired at various combinations of elevations and charge weights.

b. Maximum ordinate (summit) of the projectile fired at various combinations of elevations and charge weights. This is important with regard to air space requirements.

c. Azimuth at which the weapon is positioned.

d. Drift, for artillery firing in particular, caused by the spin of the projectile. Such drift for US weapons is always to the right; correction of the weapon is to the left.

e. Probable errors in both range and deflection.

f. Meteorological conditions (air density, temperature, and wind speed and direction (surface and aloft)), which affect range and deflection.

g. Components of the projectile (sabots, spacer plates, etc.) discarded in flight.

h. Ricochet characteristics which will increase the down-range distance of travel for the projectiles fired at low angles of elevation and may increase the deflection, i.e., where the projectiles finally come to rest relative to the line of fire and initial point of impact. Ricochet is affected by the angle of impact and the type and slope of the impact surface.

i. Stability and control of the launching system. For example, if there are positive controls that prevent elevation above a certain amount, smaller danger zones are permissible than if the elevation could easily be altered through human error or mechanical weakness. The jump and hop of the gun are also factors.

j. Target movement - moving targets require a wider danger area.

k. Movement of the stabilized launching platform (e.g., tank), which could cause more dispersion.

l. Modifications of the projectile that alter flight. For example, spoiler plates, attached to projectiles to reduce range, will permit a reduction in down-range danger areas.

m. Types and distances of targets. Firing at armor plate, for example, can result in fragments flying considerable distances.

n. Blast/overpressure levels at crew and spectator positions, that could damage hearing.

o. Fragmentation which increases the danger area of the target area. Inert projectiles will not produce fragmentation initiated by explosives, but if fired at low angles, will have a ricochet potential, and some, such as armor-piercing fin-stabilized discarding-sabot (APFSDS) projectiles, are frangible and may produce hazardous fragments on impact.

p. Rearward debris, such as that which results from firing recoilless rifles, rockets, and missiles.

q. Dangers from excess pressure, misfires, prematures, and cookoffs, which could cause projectile detonations within the weapon or just beyond the muzzle. (Although important, these factors are not considered as part of this study, since they require special procedures that are already documented.)

r. Effects of earth's rotation on artillery projectiles.

3.2 Explanation of Terms Related to the Surface Danger Zone Diagram. (See fig. 1, 2, 3, and 4. Other danger zone diagrams are available in ARs 385-62/63.)

a. Surface danger zone - that segment of the range area which is endangered by a particular type of weapon firing and consists of the areas below. Personnel within this area are carefully controlled and protected.

b. Target area - the point or area to be covered by fire.

c. Impact area - the principal danger area for indirect-fire weapons that is established for the impact of all rounds in the firing program. When applied to direct-fire weapons, it is that area between established range limits. The impact area will be within the approved surface danger zone. The impact area includes a target area plus buffer zones to cover dispersion in range and deflection.

d. Moving target area - a lateral increase in the target area to accommodate firing at moving targets. When used, the moving target area extends the right and left limits of fire. (This is a primary danger area where no personnel or equipment are permitted except under approved conditions.)

e. Ricochet area - the area between the impact area and area A, which is provided to contain ricocheted projectiles. It is not applicable to indirect-fire weapons.

f. Area A - the area (secondary danger area) that parallels the impact area laterally and is provided to contain fragments from items exploding or ricocheting on the right or left edge of the impact area.

g. Area B - the area (secondary danger area) on the down-range side of the impact area and area A, which is intended to contain fragments from items exploding on the far edge of the impact area.

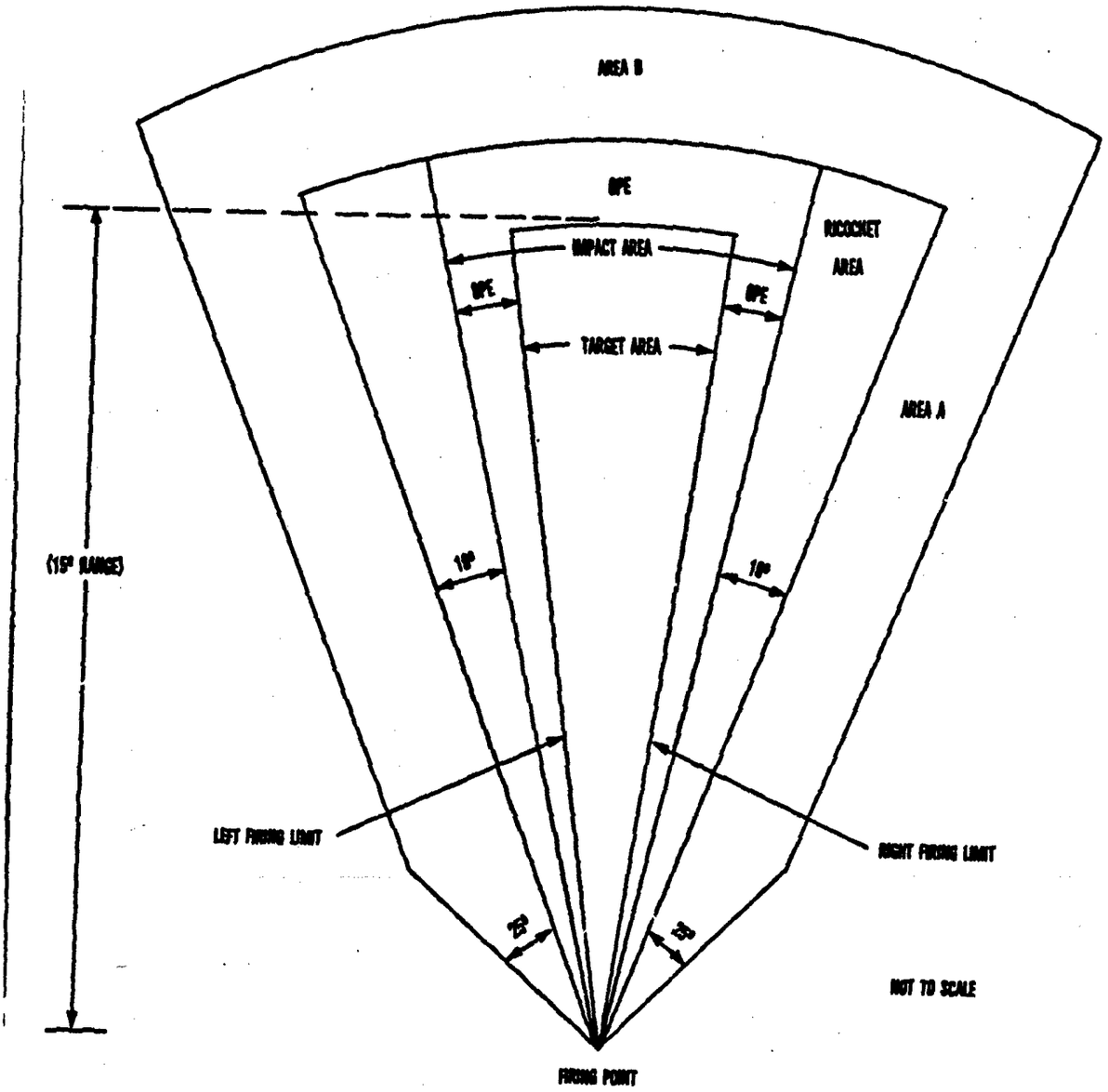


Figure 1. A typical surface danger zone diagram from AR 385-63. This is for all cannon (except tank) firing at targets in the direct mode. (The lack of adequate clearance when using direct fire prohibits personnel from occupying any area between weapon and target.)

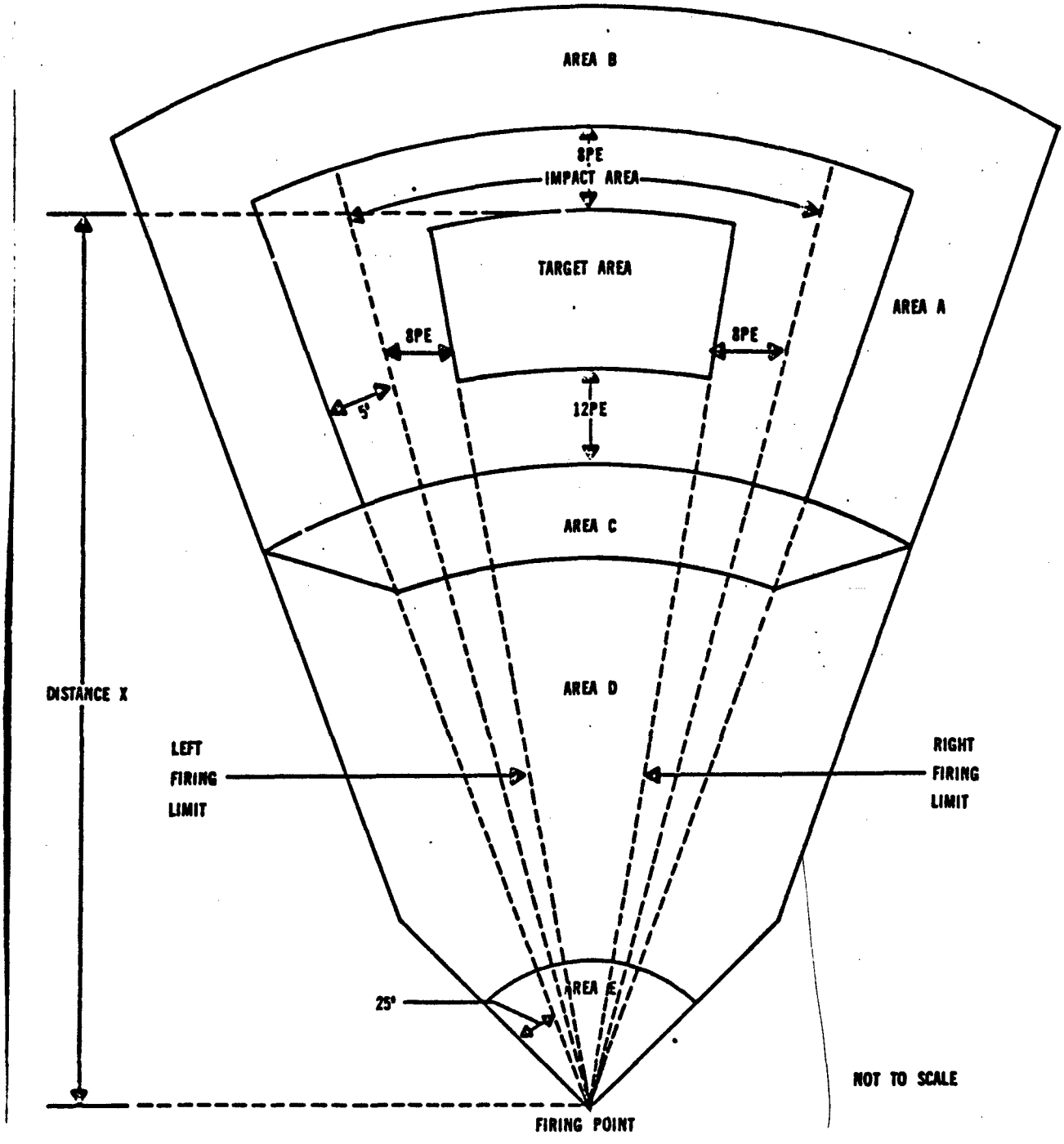


Figure 2. A typical surface danger zone diagram from AR 385-63. This is for all cannon (except tank) firing at targets in the indirect mode. Personnel are permitted to occupy area D.

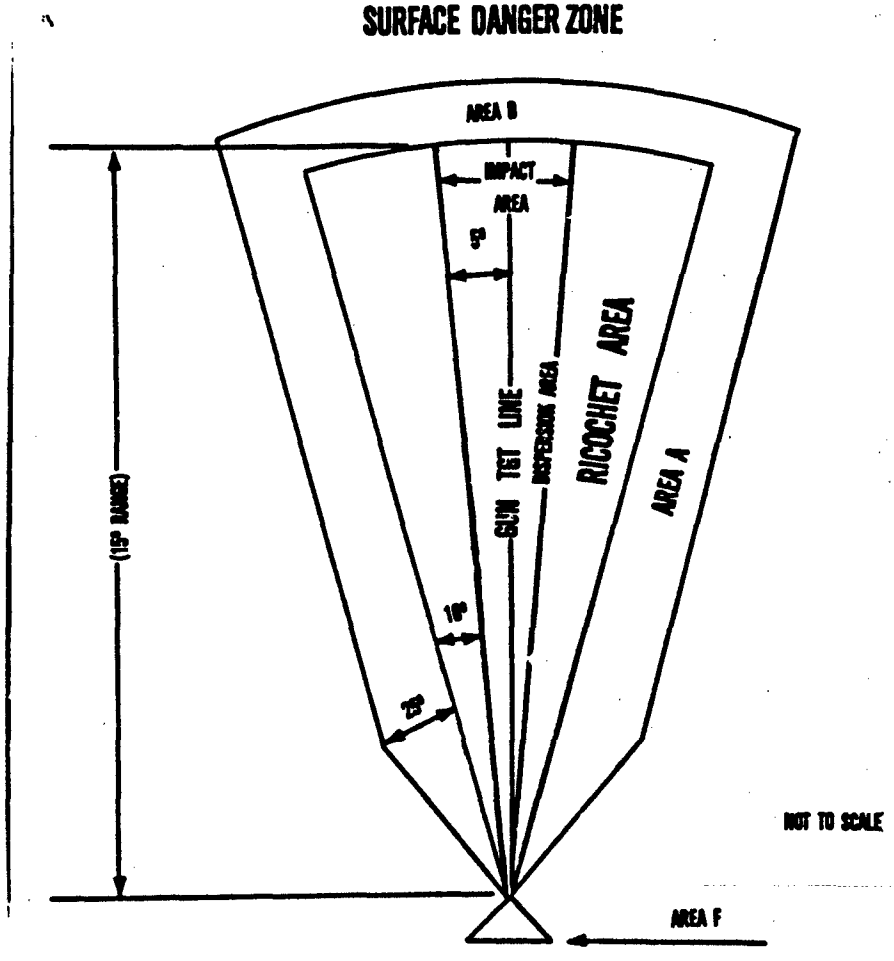


Figure 3. A typical surface danger zone diagram from AR 385-63. This is for recoilless rifles firing at a quadrant elevation of less than 15°.

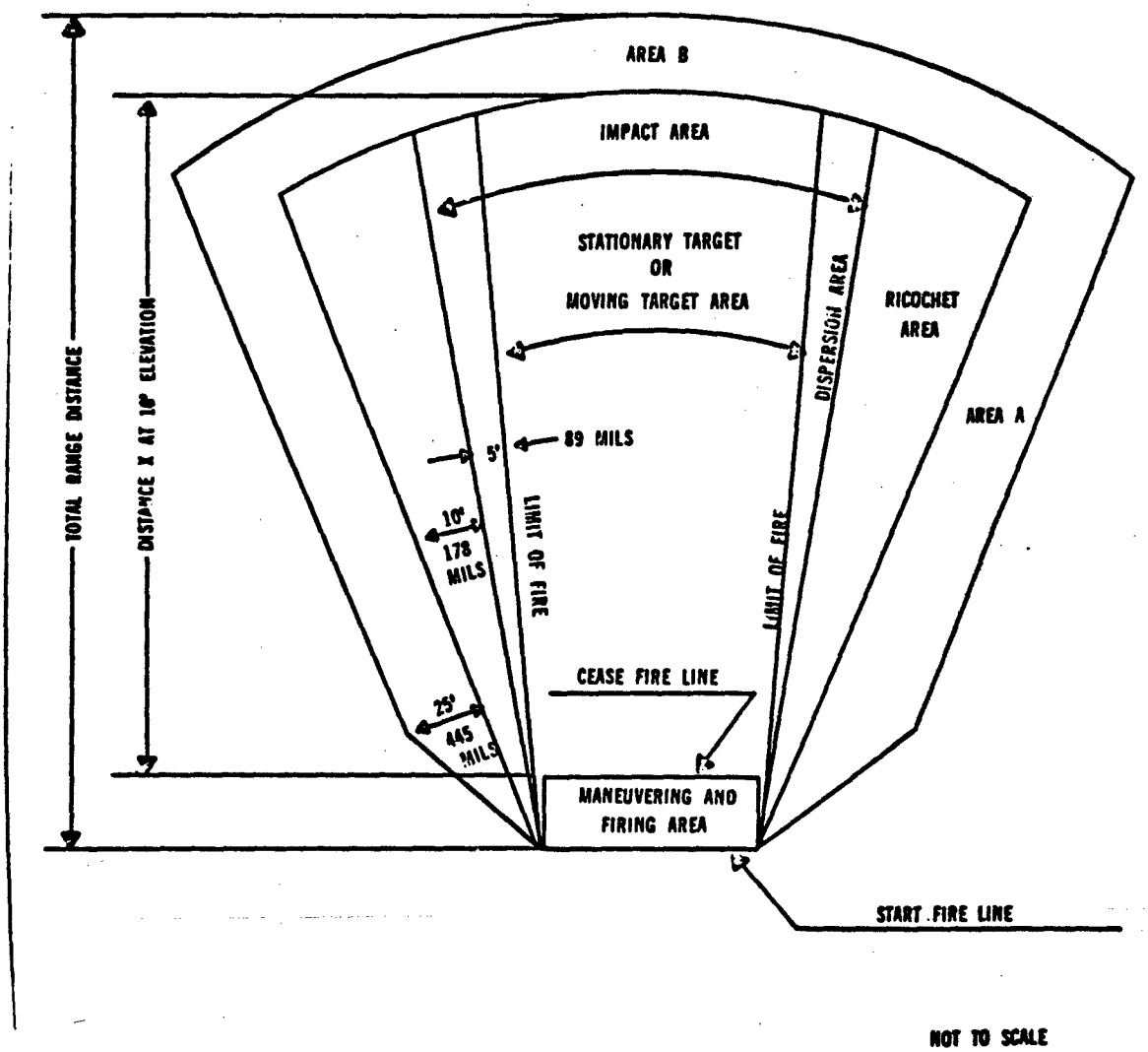


Figure 4. A typical surface danger zone diagram from AR 385-63, Change 1. This is for one or more tanks firing on the move.

h. Area C - the area (secondary danger area) on the uprange side of the impact area and parallel to area B, which is intended to contain fragments from items exploding at the near edge of the impact area (also referred to as the short limit of the target area).

i. Area D - the area between area C and area E, which is considered safe for troop occupation for training purposes. Once areas C and E are determined, area D falls between them. For tank cannon or mortars, area D does not exist. (Special precautions, including clearances related to troops, are in ARs 385-62/63. The trajectory must clear troops in area D by 5 m plus 2 forks. A fork is the change in angle of elevation necessary to produce a change in range to the center of impact equivalent to four probable errors.)

j. Area E - the area forward of the firing position, which is endangered by muzzle debris, overpressure, discarding sabots, and injurious noise levels. (This is a primary danger area.)

k. Area F - the area immediately to the rear of a weapon or group of weapons, which is endangered by the effects of the weapon(s) being fired.

l. Probable Error (PE) - a measure of the impact distribution in the dispersion pattern around the center of impact, dimensionally expressed in firing tables as one interval of the dispersion rectangle (ref 385-63).

m. Dimension X:

1) Small arms - equal to maximum range.
2) Artillery weapons - the maximum range of the weapon at the elevation to be fired and for the charge used. When in direct mode, dimension X will not be less that the range of the weapon corresponding to an elevation of 267 mils for the charge used.
3) Tank guns - direct fire mode at fixed or moving targets equal to total range distance corresponding to 10° (178-mil) quadrant elevation, an allowance for maneuver area and area B.

n. Area encompassing eight PE's - In deflection, this area has a width of eight deflection PE as determined in proving ground tests. In range, this area has a depth of eight range PE. (NOTE: In some instances 12 PE are used.)

4. TEST PROCEDURES. Conduct the following test phases:

a. A firing tables subtest in accordance with TOP 3-2-601[3] which will provide the following for every firing condition:

(1) Maximum ordinate
(2) Range
(3) Dispersion in range and deflection
(4) Drift
(5) Wind effects
(6) Projectile weight effects
(7) Air temperature and density effects
(8) Effects of earth's rotation

NOTE: Wind effects on submunitions of Improved Conventional Munitions (ICMs) are determined by computer modeling by the Firing Tables Branch of the Ballistic Research Laboratory (BRL) of ARRADCOM. Such corrections are provided in an addendum to the appropriate firing table.

b. A fragmentation subtest. (See TOP 4-2-813.[4])

c. A noise subtest to include noise at crew positions plus the determination of a 140-dbP contour line. (See TOP 1-2-608[5].)

d. A ricochet subtest for direct-fire projectiles when the projectile or penetrator (where applicable) is of a different design or different material from the projectiles previously tested to warrant a test. Such a test would be required for most antitank projectiles. Conduct this test in accordance with TOP 4-2-814.[6]

e. A subtest (TOP 4-2-501[7]) that includes photographic coverage (TOP 4-2-816[8]) and retrieval of discarded parts, if projectiles have sabots or other discarding parts.

f. A subtest to detect and evaluate the rearward debris from recoilless rifles and rockets. (See app A.)

g. A subtest to determine downwind hazards from toxic gas, riot control (RC) agents, or smoke munition clouds.

5. DATA REQUIRED. The data required are those necessary to meet the requirements of paragraph 6 below.

NOTE: The information provided to TRADOC as a result of instructions in this TOP do not imply that the weapon and ammunition are safe to transport, handle and fire. Such information is provided separately as part of the safety release on the weapon and ammunition. Safety tests of weapons and ammunition are covered in other TOPs such as 4-2-504,[9] 3-2-805,[10] and 3-2-504.[11]

6. PRESENTATION OF DATA. Prepare data for transmittal through channels to the responsible developer in a standard five-page format (fig. 5 and 6 and tables 1, 2, and 3) which is convenient for their use and as detailed below.

a. Select appropriate surface danger zone diagram from ARs 385-62/63, or draw a more appropriate diagram. (See sample, fig. 5.)

b. Present tabulation of sample data from firing tables for each charge zone including (as a minimum):

(1) Data for 10° (178 mils) and 15° (267 mils) elevation. (The range occurring at 15° elevation is used in AR 385-63 to cover all ricochets that occur from firing at elevations of 15° or less.)

(2) The data from firing at the maximum range. (See sample, table 1.)

NOTE: The final firing tables produced by the Ballistic Research Laboratory (BRL) are not usually available for 6 months or more after the test is completed.

These tables may have slightly different values than those produced by APG-MTD because of different computer programs, different treatment of outliers, etc.

c. Using the ballistic coefficient and the form factor derived from the firing tables subtest, construct a table of a maximum ordinate for every 5° of elevation over the range of elevations of interest. (See sample, table 2.)

d. Draw the 140-dbP noise contour. (See sample, fig. 6.)

e. Draw lines on 140-dbP diagram which show travel limits of muzzle debris and backward debris. (See sample, fig. 6.)

f. If the ricochet test is conducted, list the maximum ricochet distances down range for soft earth; and for armor plate (or stone), and water, if tests also covered these surfaces. Also provide the greatest lateral deflections of ricochet. (See TOP 4-2-814, app B, pages B-9 and B-10.) If a ricochet test is not conducted, present information on what projectile or missile (in ARs 385-62/63) is believed to have similar ricochet characteristics. (See sample, table 3.)

g. Compile a table showing maximum travel of fragments from a statically detonated projectile and from projectiles detonating at airbursts of 50, 100, 150, and 200 m. Calculate velocities with data from the fragmentation test. (See sample, table 3.) At the travel distance, it is assumed there is a potential for slight injury.

h. Compile a table or prepare narrative comments addressing unclassified downwind hazard distances and/or requirements for the use of protective masks or other protective clothing/procedures for toxic gas, riot control (RC) agents, or smoke munitions.

i. In the case of ICM ammunition, if the effect of wind on the submunitions is not available in firing tables, obtain the necessary information on wind effects from BRL, and provide this information.

j. Provide recommendations or suggestions for dimensions of ricochet area (if any), areas A, B, C, E, and F, or other dimension that should be incorporated into the final surface danger area.

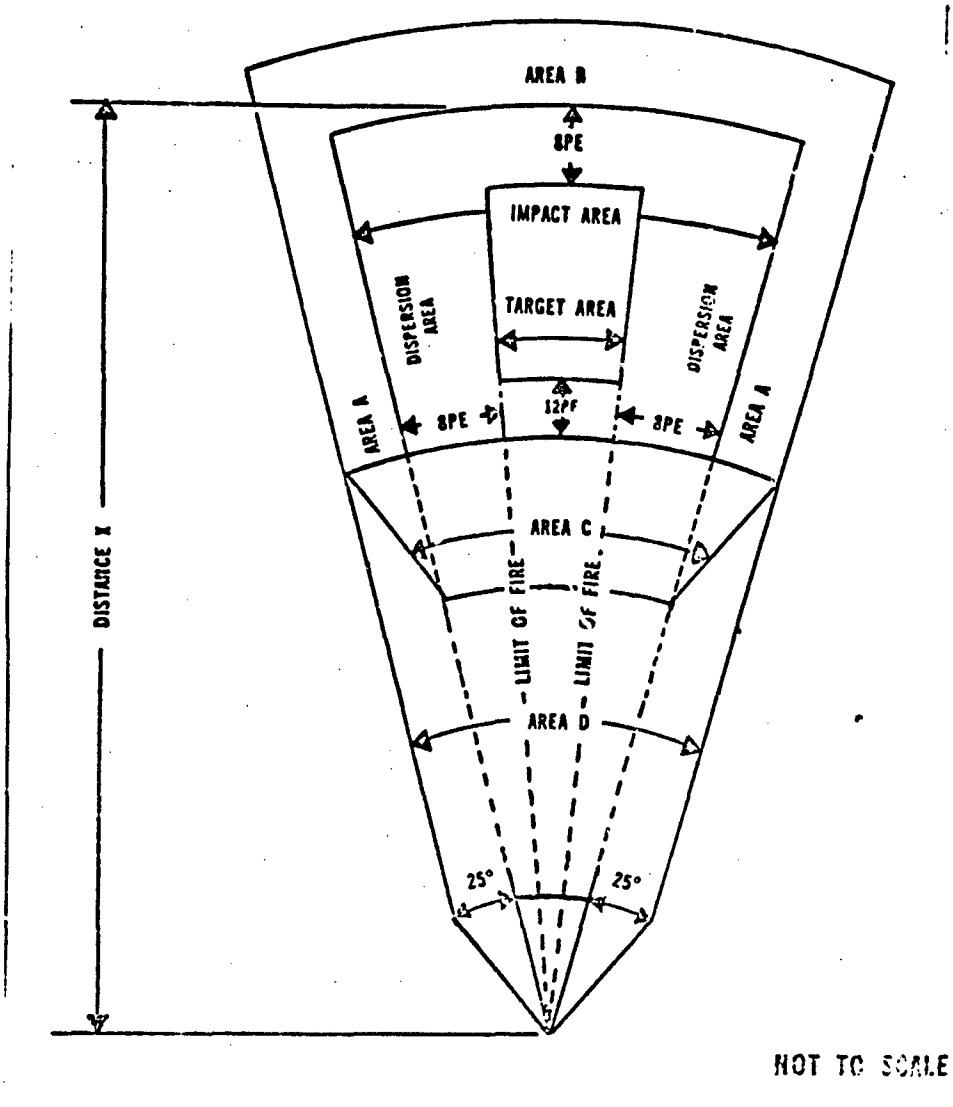


Figure 3. A surface danger zone diagram selected from AR 385-63 as best suited for the 155-mm M107 projectile fired from the M185 cannon.

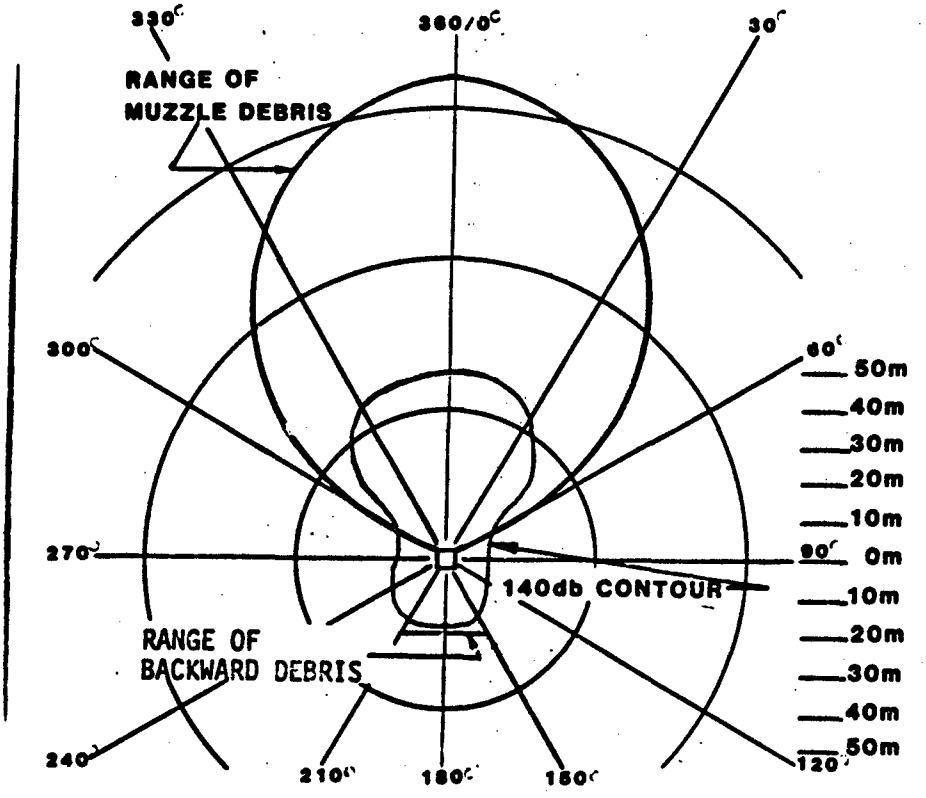


Figure 6. Diagram of 140-dbP contour and limits of muzzle and backward debris.

TABLE 1. EXAMPLE OF DATA FOR SURFACE DANGER ZONES, SELECTED DATA FROM FIRING TABLES FOR PROJECTILE, HE, M107, FROM 155-MM CANNON M185 ON HOWITZER, SP, 155-MM, M109A1

| Charge | Range, meters | Elevation, mils | Drift Corr to Left, meters | Probable Error In Range, meters | Probable Error In Deflection, meters |
|---|---|---|---|---|---|
| 1 | 1516 | 178 | 4.0 | 18 | 1 |
| | 2179 | 267 | 5.9 | 26 | 2 |
| | 4000 | 673.6 | 20.1 | 45 | 5 |
| | 4000 | 892.6 | 33.3 | 45 | 6 |
| 2 | 1890 | 178 | 4.0 | 10 | 2 |
| | 2711 | 267 | 6.2 | 14 | 2 |
| | 5000 | 722.4 | 22.5 | 32 | 6 |
| | 5000 | 841.6 | 29.5 | 34 | 7 |
| 3 | | etc. | | | |
| 8 | | etc. | | | |

Note: For corrections for wind effects, air temperature, air density, projectile weight, and rotation of earth, see firing tables.

TABLE 2. EXAMPLE OF MAXIMUM ORDINATE DATA, M107 PROJECTILE IN M185 CANNON

| Vel, fps | Chg Zone | | Angle of Elevation, degrees | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 80 | 90 |
| 695 | 1 | o | 850 | 1280 | 1790 | 2340 | 2920 | 3520 | 4120 | 4700 | 5240 | 5730 | 6160 | 6760 | 6970 |
| | | r | 1395 | 1645 | 1845 | 1985 | 2070 | 2090 | 2050 | 1950 | 1795 | 1590 | 1335 | 710 | 0 |
| | | t | 7.2 | 8.8 | 10.4 | 11.9 | 13.3 | 14.6 | 15.8 | 16.9 | 17.8 | 18.6 | 19.3 | 20.3 | 20.6 |
| 780 | 2 | o | 1060 | 1600 | 2220 | 2910 | 3630 | 4370 | 5110 | 5830 | 6500 | 7110 | 7640 | 8380 | 8640 |
| | | r | 1735 | 2045 | 2285 | 2460 | 2555 | 2580 | 2530 | 2410 | 2220 | 1960 | 1645 | 875 | 0 |
| | | t | 8.0 | 9.9 | 11.6 | 13.2 | 14.8 | 16.2 | 17.5 | 18.7 | 19.8 | 20.7 | 21.5 | 22.5 | 22.9 |
| 960 | 3 | o | 1570 | 2370 | 3290 | 4290 | 5340 | 6430 | 7510 | 8560 | 9540 | 10430 | 11203 | 12300 | 12680 |
| | | r | 2560 | 3000 | 3345 | 3585 | 3725 | 3755 | 3680 | 3500 | 3220 | 2845 | 2390 | 1275 | 0 |
| | | t | 9.8 | 12.0 | 14.0 | 16.0 | 17.8 | 19.6 | 21.1 | 22.6 | 23.8 | 24.9 | 25.9 | 27.1 | 27.6 |
| 1105 | 4 | o | 2000 | 3010 | 4160 | 5420 | 6740 | 8110 | 9470 | 10790 | 12030 | 13160 | 14130 | 15520 | 16010 |
| | | r | 3220 | 3765 | 4185 | 4480 | 4645 | 4685 | 4590 | 4370 | 4020 | 3560 | 2990 | 1595 | 0 |
| | | t | 10.9 | 13.4 | 15.7 | 17.9 | 19.9 | 21.8 | 23.6 | 25.2 | 26.6 | 27.9 | 28.9 | 30.4 | 30.9 |
| 1290 | 5 | o | 2400 | 3590 | 4940 | 6420 | 7990 | 9610 | 11230 | 12800 | 14290 | 15640 | 16820 | 18490 | 19080 |
| | | r | 3765 | 4375 | 4860 | 5205 | 5405 | 5455 | 5355 | 5105 | 4710 | 4175 | 3510 | 1880 | 0 |
| | | t | 11.8 | 14.4 | 16.9 | 19.2 | 21.5 | 23.5 | 25.5 | 27.2 | 28.8 | 30.2 | 31.3 | 32.9 | 33.5 |
| 1560 | 6 | o | 3150 | 4610 | 6270 | 8070 | 9990 | 11970 | 13960 | 15910 | 17750 | 19430 | 20890 | 22990 | 23730 |
| | | r | 4680 | 5355 | 5890 | 6280 | 6510 | 6570 | 6455 | 6160 | 5695 | 5055 | 4260 | 2285 | 0 |
| | | t | 13.1 | 15.9 | 18.5 | 21.0 | 23.5 | 25.8 | 27.9 | 29.8 | 31.6 | 33.1 | 34.4 | 36.2 | 36.9 |
| 1855 | 7 | o | 4120 | 5940 | 7980 | 10190 | 12530 | 14950 | 17400 | 19790 | 22070 | 24160 | 25990 | 28610 | 29530 |
| | | r | 5885 | 6605 | 7180 | 7605 | 7860 | 7925 | 7790 | 7445 | 6890 | 6130 | 5175 | 2780 | 0 |
| | | t | 14.6 | 17.5 | 20.3 | 23.0 | 25.7 | 28.2 | 30.5 | 32.7 | 34.6 | 36.4 | 37.8 | 39.9 | 40.6 |
| 2245 | 8 | o | 5490 | 7850 | 10440 | 13230 | 16190 | 19250 | 22350 | 25410 | 28340 | 31040 | 33410 | 35830 | 38040 |
| | | r | 7610 | 8390 | 9005 | 9460 | 9735 | 9810 | 9655 | 9250 | 8580 | 7655 | 6475 | 3495 | 0 |
| | | t | 16.5 | 19.6 | 22.6 | 25.5 | 28.4 | 31.1 | 33.7 | 36.2 | 38.5 | 40.5 | 42.2 | 44.6 | 45.4 |

o = Ordinate in feet at trajectory summit.
r = Range (in meters) to maximum ordinate.
t = Time (in seconds) to maximum ordinate.

TABLE 3. EXAMPLE OF MISCELLANEOUS RANGE SAFETY DATA

Projectile:
Weapon:

| Characteristics | Meters |
|---|---|
| Maximum range of fragments | |
| Projectile at ground level | 520 |
| Projectile 50 meters high | 560 |
| Projectile 100 meters high | 600 |
| Projectile 150 meters high | 630 |
| Projectile 200 meters high | 660 |
| Maximum ricochet, downrange distance[a] | |
| From earth | 520 |
| From steel, stone | 480 |
| From water | 390 |
| Maximum ricochet, in a lateral direction[a] | |
| From earth | 170 |
| From steel, stone | 210 |
| From water | 180 |
| Maximum height of ricochet | |

Note: All figures are examples and are not based on actual data.

[a]Assumes worst case, i.e., end-on flight of ricocheting projectile.

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# APPENDIX A

## TESTS FOR REARWARD DEBRIS

1. TEST PROCEDURE FOR RECOILLESS RIFLES.

a. Method.

(1) Mount four chipboard and four wallboard panels approximately 1 to 1-1/2 m square, to wood frames. Eight are positioned as described below for each round fired.

(2) Locate four chipboard panels rearward 30° and 60° to either side of the extended horizontal centerline of the recoilless rifle and facing the firing direction. Place the two left panels 12 m from the breech and the two right panels 9 m from the breech for rounds 1 through 5. After the last round is fired, move the left and right panels to 6 and 3 m, respectively, from the breech.

(3) Locate the four wallboard panels, facing the direction of firing, directly to the rear of the recoilless rifle. Place one panel at the extended horizontal centerline of the recoilless rifle, one panel 5° to the right of the centerline, and one each 5 and 10° to the left of the centerline. Distances for these panels from the rifle breech are 25 m for rounds 1 through 5, 30 m for rounds 6 through 8, and 40 m for rounds 9 through 11.

(4) Mount the recoilless rifle on a test facility mount and elevate it 24 mils to represent a midrange firing mission. The center of the breech should be about 100 cm above the ground.

(5) Cover the ground directly behind the recoilless rifle with pea-sized, coarse-crushed stone to a depth of 5 to 7 cm.

(6) Examine the panels after each round is fired for evidence of debris penetration and unburned propellant grains.

(7) If penetrations of the wallboard occur, move the panels back in 7.5-m increments, until no penetrations occur. At the farther distances, chipboard may be substituted for wallboard, or aluminum foil may be placed on the surface of the wallboard to make detection easier.

b. Data Required. Record the following:

(1) Type, size, and location of all witness material.

(2) Number of penetrations in each panel of witness material.

(3) Blast damage to witness material.

(4) Weapon and type of ammunition used.

c. Presentation of Data.

(1) Determine penetrations per square meter for each location of witness material.

(2) Determine distance at which no penetrations occur.

2. TEST PROCEDURE FOR SMALL ROCKETS AND GUIDED MISSILES.

a. Method.

(1) Mount panels of chipboard, approximately 1 to 1-1/2 m square, to wood frames. For each firing, seven are positioned as described below.

(2) Locate four chipboard panels rearward at 30° and 60° to either side of the extended horizontal centerline of the launcher of the rocket or guided missile and facing the firing direction. Place the panels 3 m to the rear for rounds 1 through 5. After the last round is fired, move the panels back 1 m at a time for subsequent firings.

(3) Locate three additional chipboard panels, facing the direction of firing, directly to the rear of the launcher for the rocket guided missile. Place one panel directly behind the weapon (0°) and one each 10° to the left and right of the centerline. Distances for these panels from the rocket or guided missile are 6 m for rounds 1 through 5. Move the panels 1 m for subsequent firings, and fire 3 rounds at each position.

(4) Move the chipboards back along their angle until no penetrations occur. (If no penetrations occur move the panels closer until penetrations occur.)

b. Date Required. Record the following:

(1) Type, size, and location of all witness material.

(2) Number of penetrations of each panel of witness material.

(3) Blast damage to witness material.

(4) Weapon used.

c. Presentation of Data.

(1) Determine penetrations per square meter for each location of witness material.

(2) Determine distance at which no penetrations occur.

## APPENDIX B

## REFERENCES

1. AR 385-63, Policies and Procedures for Firing Ammunition for Training, Target Practice, and Combat, 15 October 1983.

2. AR 385-62, Regulations for Firing Guided Missiles and Heavy Rockets for Training, Target Practice, and Combat, 5 January 1977.

3. TOP 3-2-601, Firing Tables Test and Ballistic Match Test. (In Process)

4. TOP 4-2-813, Static Fragmentation Tests of High Explosive Munitions, 31 January 1980.

5. TOP 1-2-608, Sound Level Measurements, 17 July 1981.

6. TOP 4-2-814, Ricochet of Direct-Fire Projectiles, 2 September 1982.

7. TOP 4-2-501, Projectiles, 1 April 1979.

8. TOP/MTP 4-2-816, Photographic Instrumentation for Trajectory Data, 28 December 1966.

9. TOP 4-2-504, Safety Evaluation - Artillery, Mortar, and Recoilless Rifle Ammunition, 1 April 1979.

10. TOP 3-2-805, Safety Evaluation of Cannon and Recoilless Rifles, 12 July 1977.

11. TOP 3-2-504, Safety Evaluation of Hand and Shoulder Weapons, 1 March 1977.